Space Weather Technical Forecast

Issued on Tuesday, 20 December 2022 at 01:27 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of M-class flares and Minor Geomagnetic Storms.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low, with occasional mid-high level C-class flares observed at GOES16, peaking with a C8.0 flare at 19/1429UTC from AR3169 (Esi/Beta-gamma), the largest and most active region at present. There are six other sunspot regions on the visible disc. Of these, AR3163 in the southwest is the next largest group. This has simplified slightly during the period, though is still a moderately complex Eao/Beta region. All other groups remain unipolar or simple bipolar regions with little change observed. The most noteworthy of these is AR3171 (Dso/Beta), a newly numbered area in the far northeast of the visible disc.

There remain numerous filaments on the earth-facing disc, one of which erupted from the centre northern disc around 19/2130 UTC. This was a relatively small filament, but will be analyzed for any potential Coronal Mass Ejections (CMEs) as and when sufficient imagery becomes available. Additionally, a number of high-speed jets of plasma have emanated from the region around AR3169. It is possible one of these has resulted in the lift-off of another small filament located just to the south of the group, though again, will require more imagery to confirm this. There were numerous CMEs observed on Lasco coronagraphs in the period, though none appear Earth-directed with the largest associated with a C-flare from AR3167 in the northwest after 19/1100 UTC and passing well ahead of Earth orbit.

Solar Wind / Geomagnetic Activity: Solar winds, as observed at L1 by ACE and DSCOVR have remained at background levels throughout, between 300km/s to 360 km/s. The Density increased from average (6-10 ppcc) to above average for the period 19/0040-0435 UTC, with a peak of 45ppcc at 19/0311 UTC. Following this density has been at average or below average levels. The total magnetic field was generally moderate (8-15 nT), but briefly peaked to become strong (16nT) at 19/0124 UTC. The north-south component was mainly negative, peaking at -13 nT at 19/0500 UTC. The phi angle was negative (towards the Sun throughout). The solar wind profile suggests a CIR followed by the negative high speed stream from coronal hole 54, albeit very slow. There may also have been some minor CME effects encompassed within. Resultant geomagnetic activity was mainly Quiet to Unsettled (Kp 1-3), but with an Active (Kp 4) interval 19/0300-0600 UTC.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) as measured at GOES16 remained at Background levels. High energy electron flux (greater than 2 MeV), as observed by GOES16, was at Background to Moderate levels. The associated 24-hour fluence was well below Active (1e8 integrated pfu). Observed fluence at 20/0001UTC was 1.11e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is currently Low. There is a chance of this increasing to Moderate at times due to isolated M-class flares, and a slight chance of an X-class flare. There are currently seven sunspot regions on the disc, with a couple of moderately large, complex regions;

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one in the northeast, the other in the southwest. Successive departures over the western solar horizon through the period may be compensated for by potentially large arriving regions in the east, although this aspect of the forecast carries low confidence, and for now the risk is held constant throughout.

Solar Wind / Geomagnetic Activity: A CME from 18th December may produce a glancing blow at Earth on Day 2/3 (21st/22nd), but carries low confidence. Two potential candidate CMEs are awaiting further coronagraph imagery to determine if they could be earth-directed. The period, otherwise, will be characterized by the effects of two high-speed streams. One affecting earth from the start of Day 1(20th) and another stronger coronal hole arriving on Day 1 or Day 2 (21st), likely bringing Elevated or Strong solar winds. Geomagnetic activity is forecast (but with lower than average confidence) to be mainly Quiet initially, but increasing to Unsettled to Active late on Day 1 (20th), with a chance of G1/Minor Storm conditions. This continues into Day 2, but the risk should gradually reduce with time, allowing more prolonged periods of Unsettled, then Quiet activity by Day 3 (22nd) onwards, in the absence of any potential CME effects.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at Background levels throughout, although there is slight chance of S1+ level storms with the occurrence of any notable flares. High energy (greater than 2 MeV) electron flux is currently at Background to Moderate flux, and expected to persist at these levels. The associated 24-hour fluence is expected to continue well below the Active (1e8 integrated pfu) threshold with a mostly flat trend anticipated.

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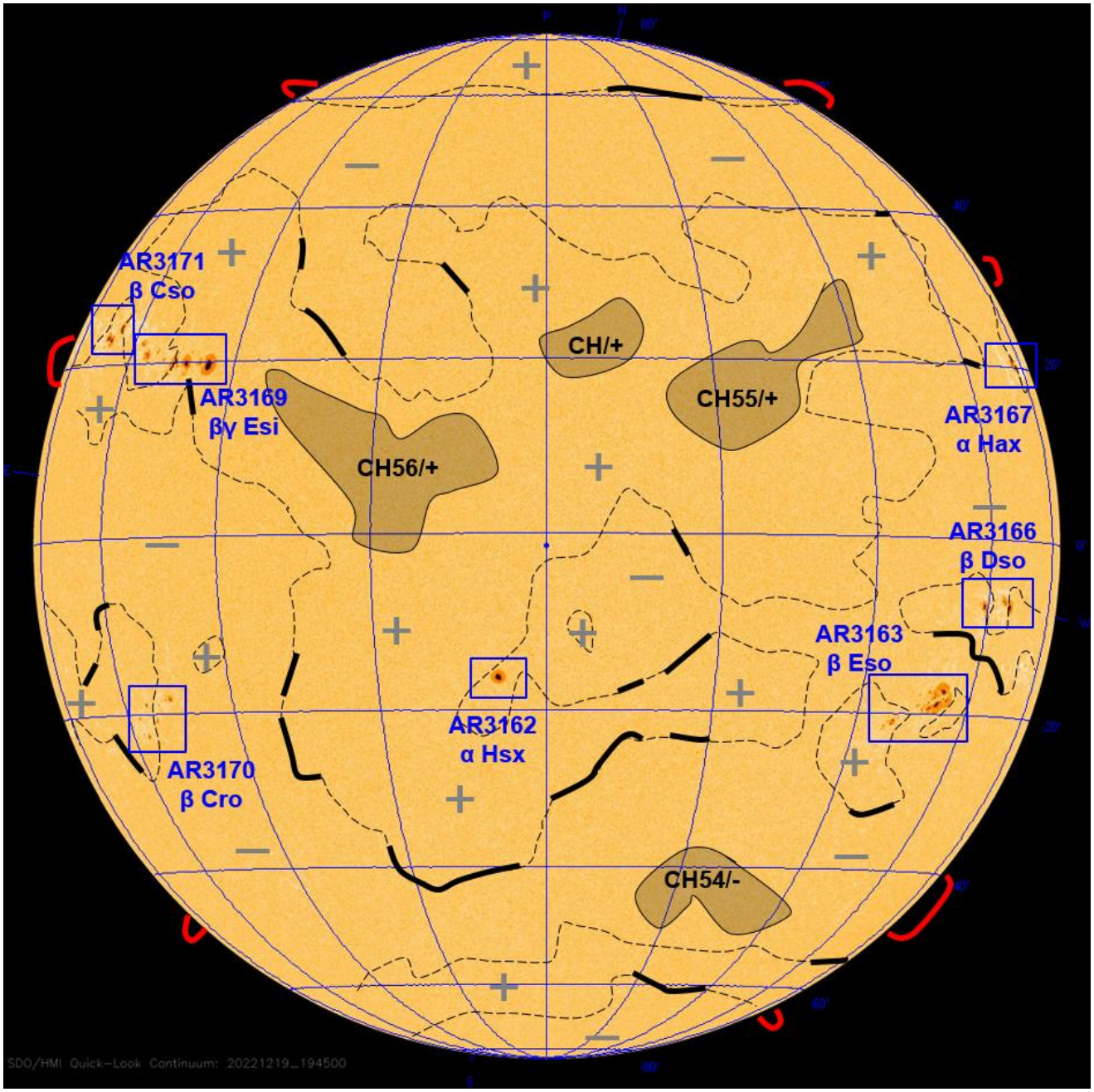
Figure 1. Solar Analysis Valid 19/1945 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

Earth appears to be in the high speed stream of CH54/-, although wind speeds still remain rather slow (around 350km/s). It is possible that a further enhancement could take place on Day 1 (20th) based on measurements from STEREO A upwind. It sampled a strongly negative Bz on the 18th (peaking at -22nT at 1450 UTC) and an increased solar wind of around 400km/s on the 19th. The solar parameters observed were consistent with a negative HSS such as from CH54/-. These effects would have been expected to have been encountered at earth already (with an approximate 1.1 day lag from STEREO A) and also given earth's more favourable position, below the ecliptic, to the southern coronal hole. This means that confidence in Geomagnetic activity is unusually low for Day 1 and Day 2. Furthermore, the onset of the HSS from CH55/+ in the northern hemisphere is anticipated entering Day 2 (21st). This is a recurrent feature with speeds in excess of 500km/s probable. Owing to an apparently more advanced western edge to this coronal hole than on the last rotation, it may just arrive at the very end of Day 1 (20th), however, confidence in this is low because, surprisingly, STEREO A (located above the ecliptic) has at the time of writing, still yet to encounter a CIR with the signature of a positive HSS. Elevated or perhaps strong winds are expected to continue through the remainder of the period. There is also a slight chance late on Day 2 (21st) into Day 3 (22nd) of a glancing blow from a CME which left the Sun on the 18th December but confidence is low.

There remain numerous filaments on the earth-facing disc, one of which erupted from the centre northern disc around 19/2130 UTC. This was a relatively small filament, but will be analyzed for any potential Coronal Mass Ejections (CMEs) as and when sufficient imagery becomes available. Additionally, a number of high-speed jets of plasma have emanated from the region around AR3169. It is possible one of these has resulted in the lift-off of another small filament located just to the south of the group, though again, will require more imagery to confirm this.

Geomagnetic activity is forecast (but with lower than average confidence) to be mainly Quiet initially, but increasing to Unsettled to Active late on Day 1, with a chance of G1/Minor Storm conditions. This continues into Day 2, but the risk should gradually reduce with time, allowing more prolonged periods of Unsettled, then Quiet activity by Day 3 (22nd) onwards, in the absence of any potential CME effects.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	40	40	20	5
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
18/1555	Partial	AR3162	SW	455 km/s	21-22 Dec	Low confidence

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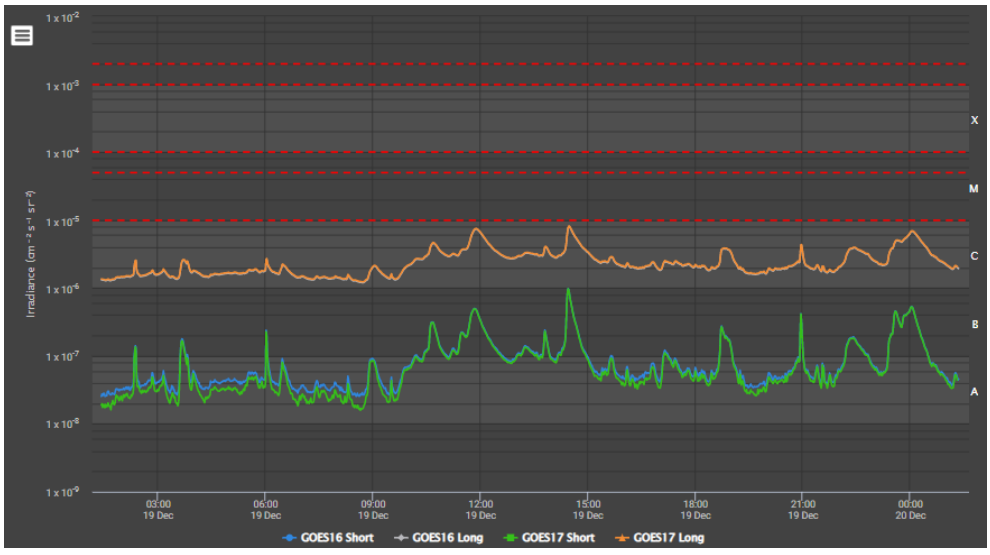
Radio Blackouts - X-Ray Flares:

There are seven sunspot regions on the visible disc. AR3169 in the northeast is the largest and most complex and active sunspot region on the visible disc, with an Esi/Beta-gamma configuration. Some slight growth of the intermediate part of the group has been evident in recent hours. AR3163 (Eso/Beta) in the southwest also appears broadly similar, although there may be some recent growth surrounding the largest portion of the group. AR3166 in the southwestern quadrant has decayed slightly. AR3170 in the southeast continues its slow growth, with rudimentary penumbra and some feint intermediary spots. All other regions remain unipolar or simple bipolar groups with little change observed. A new area of plage, perhaps containing a sunspot group is currently rotating over the northeastern limb, but is too foreshortened in imagery to make a confident assessment of this feature.

The front-side population of sunspot groups is likely to be in a constant state of flux in the period, with the successive departures of AR3163, AR3166 and AR3167 over the western horizon perhaps countered by new regions arriving over the eastern limb. Of particular interest is a large region in the northern hemisphere, suggested by far-side soundings and some halo CMEs in the last working week. This may arrive into the current UTC working week to bolster the recently-reduced risk of significant flares, although any contribution from this has yet to be determined.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	40	40	40	40
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 2: X-Ray trace past 24 hours



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Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) will most likely continue at Background levels, however there is a slight chance throughout of a S1+ event. This chance is held slightly higher when compared with the raw disc probabilities at first due to the presence of Ex-AR3165, which remains in a geoeffective location just over the southwestern solar horizon for the time being. There is also the possibility of an increase in probabilities later in the period with recent far-sided CME and flare activity approaching the east limb, but this will be assessed as and when these present for analysis.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	≥ S1	No	10	10	10	10
Very Active	≥ S3 *	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

High energy (greater than 2 MeV) electron flux is following a stable low magnitude diurnal oscillation at present. Whilst CH54/- is presently geo-effective and CH55/+ will become geo-effective later in the period, neither is currently envisaged as being capable of giving Active 24-hour integrated fluence, on a par with previous rotations. Confidence in this is perhaps lower than average, with both of these coronal holes' geometries changed since last pass, as well as the possible complicating presence of one or more CMEs. For its part, MOSWOC REFM suggests current modest electron fluence levels should persist throughout, although this does not allow for any transient activity.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	≥ 2 MeV ≥ $1x10^8$	No	1	5	10	10
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

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Figure 3: GOES16 Electron Flux (above) and MOSWOC REFM output (below)

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